

## DESCRIPTION

## CHROMATOGRAPHY MEDIUM AND ITS MANUFACTURING METHOD

## TECHNICAL FIELD

The present invention relates to a chromatography medium for qualitatively or quantitatively analyzing a liquid sample and its manufacturing method and, more particularly, to a medium on which a liquid sample spreads uniformly.

## BACKGROUND ART

Conventionally, a measuring method by chromatography, which utilizes an antigen-antibody reaction or enzyme reaction is generally used as a method for implementing a chemical test for liquid samples such as examination of water and urinalysis, or a clinical test. Usually, the chromatography is a method for separating a mixture according to its components.

Figure 8 is a diagram illustrating a conventional chromatography medium which is used for measurement by the chromatography.

In figure 8, a chromatography medium 100 has a reactive layer carrier support body 101 which supports a chromatography material, a sample application part 102 to which a liquid sample is applied, a marker hold region 103 which holds a marker reagent which can be moved by permeation of the liquid

sample, a reactive layer 104 in which a binding reaction is processed between the marker reagent having a substance that is specifically bound to an analysis target included in a liquid sample which flows therein and the analysis target, a specific protein immobilization part 105 in which a specific protein that specifically processes a binding reaction with an analysis target such as an antibody and an antigen according to a reaction format is immobilized on the region of the reactive layer 104, and a water-absorbing part 106 for absorbing the liquid sample which flows therein.

Next, a measuring method using the conventional chromatography medium 100 will be described.

When a liquid sample is applied to the sample application part 102, the liquid sample permeates the sample application part 102 and reaches to the marker hold region 103. Then, a marker reagent held in the area of the marker hold region 103 is dissolved due to the permeation of the liquid sample and permeates the reactive layer 104 with the liquid sample. On the region of the reactive layer 104, there is the specific protein immobilization part 105 in which a specific protein is immobilized, and when the liquid sample includes an analysis target, the specific protein processes an antigen-antibody reaction with a complex of the analysis target and the marker reagent, and some color reaction is seen in the region of the specific protein immobilization part 105. This color reaction

is measured visually or by adopting a detection device. On the other hand, when the liquid sample does not include an analysis target, no antigen-antibody reaction is processed nor no color reaction is seen. The liquid sample is finally absorbed into the water-absorbing part 106, and the reaction is ended. As described above, in the measuring method using the chromatography medium, since the result of the test is shown in the color reaction and thus its judgement is quite easy, it is widely applicable and further can be utilized for test of various analysis targets. However, the measurement using the chromatography medium makes a liquid sample spread on the medium and confirms the color reaction. Therefore, a more uniform spread pattern of the liquid sample on the medium is required for obtaining an accurate measurement result, and further a reaction between the marker reagent and the liquid sample on the reactive layer 104 is affected by the spread speed of the liquid sample, whereby an improvement in the permeation of the liquid sample to the reactive layer 104 is also required.

Conventional examples of the chromatography medium are disclosed for example in Japanese Published Patent Application No. Sho.62-71861 and No. Hei.11-153601.

Japanese Published Patent Application No. Sho.62-71861 discloses a method by which a surface active agent having a HLB (hydrophile-liophile balance) value which is larger than 20 is

applied to promote a reaction, thereby detecting an analysis target speedily, in measurement employing immunity principles. Further, the Japanese Published Patent Application No. Hei.11-153601 discloses a method by which an additive impregnating part which carries a surface active agent or the like is provided between the sample application part and the reactive layer, and a decrease in a S/N ratio and an erroneous operation due to the coloring of a background and the generation of a blank is prevented, whereby an analysis target is detected accurately and speedily.

However, for the chromatography medium, there is conventionally no means for mechanically controlling a permeation speed of a liquid sample, and thus it is impossible to artificially control the permeation speed, whereby the permeation speed of the liquid sample depends on the permeability of the medium. Thus, a considerable time may be required till the liquid sample permeates the medium, the permeation of the liquid sample to the reactive layer 104 may not be uniform, or a reactive component immobilization part such as the specific protein immobilization part 105 may have a part which is not permeated by the sample, thereby lacking precision in measurement. To solve these problems, a surface active agent processing is executed to the medium to enhance the permeation performance of the chromatography medium. However, when a surface active agent whose original property is

in liquid or paste form is used as the surface active agent to be adopted for the surface active agent processing, it is impossible to dry the surface active agent up to an absolute dry condition. Thereby, an immobilized antibody is gradually devitalized during a conservation period of the chromatography medium and the performance of the medium is deteriorated, whereby a quality maintenance period of the medium is shortened or a storage condition of the medium is restricted.

In the chromatography measurement, a liquid sample is applied on a medium, and a color area where a color reaction is processed a prescribed period of time after the application of the liquid sample is measured. Therefore, when the medium is subjected to a surface active agent processing, a marker reagent processes a nonspecific adsorption to the reactive layer 104 and the marker reagent remains on the reactive layer as a background, and thus the value of the background is added to an essential degree of the coloring to include an error when the color area is detected by adopting a detecting instrument, whereby a quantitative performance is reduced. Also when the color reaction is visually judged, the color of the background leads to an erroneous recognition in the judgement of the essential color situation.

When the method disclosed in the Japanese Published Patent Application No. Sho.62-71861 is adopted, a surface active agent having a HLB value which is higher than 20 is

applied to increase the permeability of the medium. Therefore, the permeability and the permeation speed of the medium is surely increased, while the permeation speed is too high to perform a sufficient reaction required for the measurement, resulting in the lack of the precision in measurement.

Further, when the measurement is performed by adopting the chromatography medium as disclosed in the Japanese Published Patent Application No. Hei.11-153601, since the surface active agent is impregnated on a region situated forward the reactive layer on the medium, the surface active agent does not exist in a reactive component immobilization part such as the specific protein immobilization part, whereby influences of the background can be reduced and reactive components of the medium are not devitalized nor denatured. However, the sample does not sufficiently permeate the reactive components in the immobilization area in a stage where the permeation is developed, whereby the reaction is not performed uniformly, resulting in the lack of precision in measurement.

The present invention is made to solve the above-mentioned problems and has for its object to provide a chromatography medium and its manufacturing method which minimize the quantity of a marker reagent remaining in the background, enhance the reactivity by improvement in the permeability of a liquid sample and a more uniform spread of the liquid sample, and enhance the preservation stability of the chromatography medium.

## SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a chromatography medium which is obtained by laminating plural wettable porous materials or made of a single-layer porous material, in which a reactive layer on which at least one of reactive components adopted in a chromatographic analysis is immobilized includes a surface active agent having such a property that it can be solidified when dried.

Therefore, the reactivity of the chromatography medium can be enhanced due to the enhancement in the permeability of the reactive layer and the uniform permeation of a sample, thereby realizing a chromatography measurement with a higher sensitivity and a higher performance. Further, by adopting the surface active agent having such a property that it can be solidified when dried as the surface active agent, the devitalization of a reactive component immobilized on the reactive layer can be minimized, thereby realizing the enhanced preservation stability, the extended quality maintenance period, and the expanded storage condition of the chromatography medium.

According to a second aspect of the present invention, in the chromatography medium of the first aspect, the surface active agent has an HLB (hydrophilic-lipophilic balance) value which is 20 or lower.

Therefore, in addition to the effect of the first aspect, it can be prevented that the permeation speed of a liquid sample in the reactive layer is too high to obtain a sufficient reaction, and further by selecting the HLB value to control the reaction speed appropriately, a chromatography measurement with a higher sensitivity and a higher performance can be realized.

According to a third aspect of the present invention, in the chromatography medium as defined in the first or second aspect, the surface active agent comprises a nonionic surface active agent.

Therefore, in addition to the effect of the first aspect, a nonspecific adsorption of a marker reagent onto the reactive layer is avoided and it can be prevented that the marker reagent remains on the reactive layer as a background, thereby realizing a measurement by a chromatography medium with a higher sensitivity and a higher performance.

According to a fourth aspect of the present invention, in the chromatography medium as defined in any of the first through third aspects, the surface active agent comprises a cholic acid surface active agent.

Therefore, in addition to the effect of the first aspect, influence upon protein can be reduced and the denaturation or devitalization of immobilized specific protein can be minimized, whereby the performance of the reactive layer can be held for a long time.



According to a fifth aspect of the present invention, in the chromatography medium as defined in any of the first through fourth aspects, the surface active agent comprises a sugar in a hydrophilic part of the surface active agent.

Therefore, in addition to the effect according to the first aspect, the solubility is enhanced and the permeability is increased by the action of sugar, while influence upon protein can be reduced, whereby the denaturation or devitalization of immobilized specific protein can be minimized and thus the performance of the reactive layer can be held for a long time.

According to a sixth aspect of the present invention, in the chromatography medium as defined in any of the first through fifth aspects, the reactive layer includes the surface active agent in the entirety thereof.

Therefore, the reactivity of the chromatography medium can be enhanced due to the enhancement in the permeability of the reactive layer and the uniform permeation of a sample, thereby realizing a chromatography measurement with a higher sensitivity and a higher performance. Further, by adopting the surface active agent having such a property that it can be solidified when dried as the surface active agent, the devitalization of a reactive component immobilized on the reactive layer can be minimized, thereby realizing the enhanced preservation stability, the extended quality maintenance period,

and the expanded storage condition of the chromatography medium.

According to a seventh aspect of the present invention, in the chromatography medium as defined in any of the first through fifth aspects, the reactive layer includes the surface active agent in a part thereof.

Therefore, the reactivity of the chromatography medium can be enhanced due to the enhancement in the permeability of the reactive layer and the uniform permeation of a sample, thereby realizing a chromatography measurement with a higher sensitivity and a higher performance. Further, by adopting the surface active agent having such a property that it can be solidified when dried as the surface active agent, the devitalization of a reactive component immobilized on the reactive layer can be minimized, thereby realizing the enhanced preservation stability, the extended quality maintenance period, and the expanded storage condition of the chromatography medium.

According to an eighth aspect of the present invention, there is provided a method for manufacturing a chromatography medium which has a reactive layer on which at least one of reactive components adopted in a chromatographic analysis is immobilized comprising: a step of impregnating or coating the reactive layer of the chromatography medium with a surface active agent dissolved liquid in which a surface active agent having such a property that it can be solidified when dried is dissolved; and a step of drying the surface active agent

dissolved liquid with which the reactive layer has been impregnated or coated.

Therefore, the reactivity of the chromatography medium can be enhanced due to the enhancement in the permeability of the reactive layer and the uniform permeation of a sample, whereby a chromatography medium with a higher sensitivity and a higher performance can be manufactured. Further, by adopting the surface active agent having such a property that it can be solidified when dried as the surface active agent, the devitalization of a reactive component immobilized on the reactive layer can be minimized, whereby the chromatography medium having the enhanced preservation stability, the extended quality maintenance period, and the expanded storage condition can be manufactured.

According to a ninth aspect of the present invention, in the chromatography medium manufacturing method as defined in the eighth aspect, the surface active agent has an HLB value which is 20 or lower.

Therefore, in addition to the effect according to the eighth aspect, it can be prevented that the permeation speed of a liquid sample in the reactive layer is too high to obtain a sufficient reaction, and further by selecting the HLB value to control the reaction speed appropriately, a chromatography medium with a higher sensitivity and a higher performance can be manufactured.

According to a tenth aspect of the present invention, in the chromatography medium manufacturing method as defined in the eighth or ninth aspect, the surface active agent comprises a nonionic surface active agent.

Therefore, in addition to the effect according to the eighth aspect, a nonspecific adsorption of a marker reagent onto the reactive layer is avoided and it can be prevented that the marker reagent remains on the reactive layer as a background, whereby a chromatography medium with a higher sensitivity and a higher performance can be manufactured.

According to an eleventh aspect of the present invention, in the chromatography medium manufacturing method as defined in any of the eighth through tenth aspects, the surface active agent comprises a cholic acid surface active agent.

Therefore, in addition to the effect according to the eighth aspect, influence upon protein can be reduced and the denaturation or devitalization of immobilized specific protein can be minimized, whereby the chromatography medium whose performance of the reactive layer can be held for a long time can be manufactured.

According to a twelfth aspect of the present invention, in the chromatography medium manufacturing method as defined in any of the eighth through eleventh aspects, the surface active agent comprises a sugar in a hydrophilic part of the surface active agent.

Therefore, in addition to the effect according to the eighth aspect, the solubility is enhanced and the permeability is increased by the action of sugar, while influence upon protein can be reduced, whereby the denaturation or devitalization of immobilized specific protein can be minimized and thus the chromatography medium whose performance of the reactive layer can be held for a long time can be manufactured.

According to a thirteenth aspect of the present invention, in the chromatography medium manufacturing method as defined in any of the eighth through twelfth aspects, the reactive layer is dried by air drying.

Therefore, in addition to the effect according to the eighth aspect, the load to a reactive component immobilized on the reactive layer can be suppressed, thereby manufacturing a chromatography medium having the performance of the processed reactive layer which can be held for a long time.

According to a fourteenth aspect of the present invention, in the chromatography medium manufacturing method as defined in any of the eighth through twelfth aspects, the reactive layer is dried by wind drying.

Therefore, in addition to the effect according to the eighth aspect, the drying time can be shorten and the devitalization or denaturation of an immobilized reactive component during the drying can be minimized, thereby manufacturing a chromatography medium having the performance of

the processed reactive layer which can be held for a long time.

According to a fifteenth aspect of the present invention, in the chromatography medium manufacturing method as defined in any of the eighth through twelfth aspects, the reactive layer is dried by freeze drying.

Therefore, in addition to the effect according to the eighth aspect, the property of an immobilized reactive component can be almost held, thereby manufacturing a chromatography medium having the performance of the processed reactive layer which can be held for a long time.

According to a sixteenth aspect of the present invention, in the chromatography medium manufacturing method as defined in any of the eighth through fifteenth aspects, the entire reactive layer is impregnated or coated with the surface active agent dissolved liquid.

Therefore, the reactivity of the chromatography medium can be enhanced due to the enhancement in the permeability of the reactive layer and the uniform permeation of a sample, whereby a chromatography medium with a higher sensitivity and a higher performance can be manufactured. Further, by adopting the surface active agent having such a property that it can be solidified when dried as the surface active agent, the devitalization of a reactive component immobilized on the reactive layer can be minimized, whereby the chromatography medium having the enhanced preservation stability, the extended

quality maintenance period, and the expanded storage condition can be manufactured.

According to a seventeenth aspect of the present invention, in the chromatography medium manufacturing method as defined in any of the eighth through fifteenth aspects, a part of the reactive layer is impregnated or coated with the surface active agent dissolved liquid.

Therefore, the reactivity of the chromatography medium can be enhanced due to the enhancement in the permeability of the reactive layer and the uniform permeation of a sample, whereby a chromatography medium with a higher sensitivity and a higher performance can be manufactured. Further, by adopting the surface active agent having such a property that it can be solidified when dried as the surface active agent, the devitalization of a reactive component immobilized on the reactive layer can be minimized, whereby the chromatography medium having the enhanced preservation stability, the extended quality maintenance period, and the expanded storage condition can be manufactured.

#### BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a perspective view illustrating a structure of a lateral flow-type chromatography medium according to a first embodiment of the present invention.

Figure 2 is a perspective view illustrating a structure

of a flow through-type chromatography medium according to a second embodiment of the present invention.

Figure 3 is a perspective view illustrating the flow through-type chromatography medium according to the second embodiment of the invention.

Figure 4 is a perspective view illustrating the flow through-type chromatography medium according to the second embodiment of the invention.

Figure 5 is a perspective view illustrating a structure of a flow through-type chromatography medium that uses an enzyme according to the second embodiment of the invention.

Figure 6 is a perspective view illustrating the flow through-type chromatography medium that uses an enzyme according to the second embodiment of the invention.

Figures 7 are diagrams illustrating quantitative performances according to the embodiments of the present invention, figure 7(a) showing a case where a surface active agent is not adopted as a processing for a reactive layer and figure 7(b) showing a case where a surface active agent is adopted.

Figure 8 is a perspective view illustrating a structure of a conventional chromatography medium.

#### DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments according to the present



invention will be described with reference to the drawings. The embodiments described herein are given only as examples and the present invention is not restricted to these embodiments.

#### First Embodiment

Figure 1 is a diagram illustrating a lateral flow-type chromatography medium made of a wettable single-layer porous material according to a first embodiment of the present invention.

In figure 1, a lateral flow-type chromatography medium 10 has a reactive layer carrier support 1, a sample application part 2, a marker hold region 3, a reactive layer 4, a specific protein immobilization part 5, and a water-absorbing part 6.

The reactive layer carrier support 1 is made of liquid-impermeable plastic or the like, and supports a chromatography material. The sample application part 2 is made of a nonwoven fabric having high hydrophilia or the like, and a liquid sample is added or applied thereto. The marker hold region 3 holds a marker reagent on the nonwoven fabric or the like so that it can be dissolved by the liquid sample. The reactive layer 4 is made of nitrocellulose or the like, and further impregnated with a surface active agent dissolved liquid in which a surface active agent having such a property that it can be solidified when dried is dissolved and thereafter dried. The surface active agent shown here is the general term for substances which include a hydrophilic atomic group having a high affinity

with water molecules and a hydrophobic atomic group having a low affinity with water molecules in its molecule, and have properties of changing properties on the interface or surface. Further, among those surface active agents, the surface active agent having such a property that it can be solidified when dried is the one which can be massed or have a solid shape such as granules and powder when the surface active agent in a high concentration is subjected to a vacuum or freeze drying or to a drying operation at the normal pressures with the addition of heat or at the ordinary temperatures and normal pressures. Further, the impregnation process to the reactive layer 4 is a process for dipping the reactive layer 4 in the surface active agent dissolved liquid. The specific protein immobilization part 5 is obtained by immobilization a specific protein that specifically processes a binding reaction with an analysis target like an antibody or an antigen according to the reaction format on the region of the reactive layer 4. The water-absorbing part 6 finally absorbs the liquid sample. The sample application part 2, the marker hold region 3, the reactive layer 4 having the specific protein immobilization part 5, and the water-absorbing part 6 are put on the top of the reactive layer carrier support 1, thereby forming the lateral flow-type chromatography medium 10.

The marker reagent held in the marker hold region 3 and the specific protein immobilized on the specific immobilization

part 5 on the chromatography medium 10 should be selected properly according to a sample to be analyzed and an analysis target.

As the surface active agent dissolved liquid with which the reactive layer 4 is impregnated, a surface active agent which has such a property that it is solidified when dried and having a HLB value which is 20 or lower, a nonionic surface active agent, a cholic acid surface active agent, a surface active agent having sugar in a hydrophilic part and the like are used.

Here, when more preferable surface active agents which are used in the surface active agent dissolved liquid are listed, as for the one having an HLB value which is 20 or lower, one that has an HLB value which is near 20 and has a structure in which many hydrophilic atomic groups are included is more preferable. As for the one which includes the cholic acid surface active agent, one that has a cholic acid such as N, N-Bis (3-D-gluconamidopropyl) cholamide or N, N-Bis (3-D-gluconamidopropyl) deoxycholamide as its mother nucleus is more preferable. Further, as for one having a sugar in its hydrophilic part, one which has a structure in which a sugar chain such as Sucrose Monolaurate and n-Octyl- $\beta$ -D-Thioglucoside is included is more preferable. The above-described names of substances are merely examples.

While the surface active agent processing to the reactive

layer 4 is performed by the impregnation processing which impregnates the reactive layer 4 with the surface active agent dissolved liquid, it may be performed by a coating processing which coats the reactive layer 4 with the surface active agent dissolved liquid. The surface active agent processing to the reactive layer 4 can be performed either to a part or the whole of the reactive layer 4.

As the processing for drying the surface active agent dissolved liquid with which the reactive layer 4 has been impregnated, there are processings such as air drying which is a method of leaving it at ordinary temperatures and normal pressures to be dried, wind drying which is a method of applying a prescribed wind force to it at an arbitrary temperature to be dried, and freeze drying.

A chromatography material which is composed of an arbitrary porous carrier such as nitrocellulose and glass fiber filter paper is adopted as the lateral flow-type chromatography medium 10.

Next, a chromatographic analysis method which adopts the lateral flow-type chromatography medium 10 according to the first embodiment will be described.

In figure 1, when a liquid sample is applied to the sample application part 2, the liquid sample permeates the sample application part 2 and reaches to the marker hold region 3. Then, a marker reagent held in the area of the marker hold

region 3 is dissolved due to the permeation of the liquid sample and permeates the reactive layer 4 together with the liquid sample. Then, a surface active agent included in the reactive layer 4 is dissolved with the permeation of the liquid sample. By the action of the dissolved surface active agent, permeation into the reactive layer 4 is speedily performed and the permeation of the liquid sample is proceeded with the end of the permeating liquid being lined and without remaining. In the area of the reactive layer 4, there is the specific protein immobilization part 5 on which a specific protein is immobilized, and when the liquid sample includes an analysis target, the specific protein processes an antigen-antibody reaction with a complex of the analysis target and the marker reagent, resulting in some color reaction in the area of the specific protein immobilization part 5. When the liquid sample does not include an analysis target, the antigen-antibody reaction is not processed and no color reaction is seen. Finally, the liquid sample is absorbed by the water-absorbing part 6 and the reaction is ended.

As described above, according to the lateral flow-type chromatography medium 10 of the first embodiment, the permeability of the chromatography medium 10 is enhanced and a more uniform permeation is enabled by the processing for impregnating the reactive layer 4 on the chromatography medium 10 with the surface active agent dissolved liquid and the

drying processing. This enhancement in permeability and the uniform permeation of the liquid sample improve the reactivity on the chromatography medium 10, resulting in a chromatography measurement with a higher sensitivity and a higher performance.

When the surface active agents used for the surface active agent dissolved liquid with which the reactive layer 4 is impregnated include the surface active agent having such a property that it can be solidified when dried, the reactive layer 4 is in a completely dried condition until the liquid sample is applied thereto and permeates the reactive layer 4. Therefore, devitalization of the immobilized specific protein can be minimized, resulting in the enhancement in preservation stability, the extension of the quality maintenance period, and the relaxation of storage conditions on the chromatography medium 10.

In addition, when the surface active agent has an HLB value which is 20 or lower is adopted, it can be avoided that the permeation speed of the liquid sample into the reactive layer 4 becomes too high to obtain a sufficient reaction. Further, when the HLB value is selected to adjust its reaction speed appropriately, a chromatography measurement with a higher sensitivity and a higher performance can be realized.

When the surface active agent comprising the nonionic surface active agent is adopted, nonspecific adsorption of the marker reagent onto the reactive layer 4 can be avoided, the

marker reagent remains on the reactive layer 4 as the background, and a measurement error of a color reaction in the specific protein immobilization part 5 can be prevented. As the result, the measurement with a higher sensitivity and a higher performance by the chromatography medium 10 is enabled.

When the surface active agent comprising the cholic acid surface active agent is adopted, influence upon protein can be reduced, and denaturation or devitalization of the specific protein immobilized on the specific protein immobilization part 5 can be minimized, whereby the performance of the reactive layer 4 can be held for a long time.

When the surface active agent which has a sugar in its hydrophilic part is adopted, the solubility is increased and the permeability is enhanced by the action of sugar, while the denaturation or devitalization of the immobilized specific protein can be minimized since the influence upon protein is a little, whereby the performance of the reactive layer 4 can be held for a long time.

When the reactive layer 4 is dried by the air drying, the load onto the specific protein immobilized on the reactive layer 4 can be suppressed, whereby the performance of the medium 10 can be held for a long time.

When the reactive layer 4 is dried by the wind drying, the drying time can be shorten and the devitalization or denaturation of the specific protein during the drying can be

minimized, whereby the performance of the medium 10 can be held for a long time.

When the reactive layer 4 is dried by the freeze drying, the properties of the specific protein can be almost held, whereby the performance of the medium 10 can be held for a long time.

While in this first embodiment the description has been given taking the specific protein as an example of the reactive component adopted in the chromatographic analysis, a reactive component, such as an enzyme, which causes some changes before and after the reaction may be adopted. In this case, the enzyme, instead of the specific protein, is immobilized on the specific protein immobilization part 5 of the lateral flow-type chromatography medium 10, and a reactive agent, instead of the marker reagent, which is bounded with a measurement target and reacts with the enzyme so that it can be dissolved in the liquid sample is held in the marker hold region 3.

Second Embodiment            Hereinafter, a flow through-type chromatography medium according to a second embodiment of the present invention will be described with reference to figures 2, 3 and 4.

Figure 2 is a perspective view illustrating a structure of a flow through-type chromatography medium which is constituted by laminating plural wettable porous materials according to the second embodiment. Figure 3 is a perspective



view illustrating the flow through-type chromatography medium seen from the side of a sample application part. Figure 4 is a perspective view of the flow through-type chromatography medium seen from the side of a water-absorbing part for finally absorbing a liquid sample.

In figure 2, the flow through-type chromatography medium 20 has a sample application part 11, a marker hold region 12, a surface active processing part 8, a specific protein immobilization part 13, a reactive layer 14, and a water-absorbing part 15.

The sample application part 11 is made of a nonwoven fabric having a high hydrophilia or the like, and a liquid sample is added or applied thereto. The marker hold region 12 holds a marker reagent in the nonwoven fabric or the like so that it can be dissolved. The reactive layer 4 is made of nitrocellulose or the like and has the surface active processing part 8 and the marker hold region 13 on its area. The surface active processing part 8 is obtained by coating a surface active agent dissolved liquid in which a surface active agent having such a property that it can be solidified when dried is dissolved on the reactive layer 14 and then drying the same. The surface active agent shown here and the surface active agent having such a property that it can be solidified when dried are those that are described above in the first embodiment. The specific protein immobilization part 13 is

obtained by immobilization a specific protein that specifically processes a binding reaction with an analysis target such as an antibody or antigen according to the reaction format on the area of the surface active processing part 8 of the reactive layer 104. The water-absorbing part 15 has a result confirmation window 16 for seeing the result of the reaction on the reactive layer 14 and finally absorbs the liquid sample. The sample application part 11, the marker hold region 12, the reactive layer 14 including the specific protein immobilization part 13 and the surface active processing part 8, and the water-absorbing part 15 are laminated, thereby forming the flow through-type chromatography medium 20.

A marker reagent held on the marker hold region 12 and specific protein immobilized on the specific protein immobilization part 13 on the flow through-type chromatography medium 20 should be selected appropriately according to a sample to be analyzed and an analysis target.

While a surface active agent processing to the reactive layer 14 is performed by the coating processing for coating the reactive layer 14 with the surface active agent dissolved liquid, it may be performed by the impregnation processing for impregnating the reactive layer 14 with the surface active agent dissolved liquid as in the first embodiment. The surface active agent processing may be performed either to a part of the reactive layer 4 as in the second embodiment or to the

whole reactive layer as in the first embodiment.

The surface active agent included in the surface active agent dissolved liquid with which the reactive layer 14 is coated, the drying processing performed after the reactive layer 14 is coated with the surface active agent dissolved liquid, and the material of the flow through-type chromatography medium 20 are the same as those in the first embodiment, and thus their descriptions will be omitted here.

Next, a chromatographic analysis method which adopts the flow through-type chromatography medium 20 according to the second embodiment will be described.

On the flow through-type chromatography medium 20 shown in figures 2, 3 and 4, when a liquid sample is applied to the sample application part 11, the liquid sample permeates the sample application part 11 and reaches to the marker hold region 12. Then, a marker reagent held in the area of the marker hold region 12 is dissolved due to the permeation of the liquid sample and permeates the reactive layer 14 together with the liquid sample. Then, a surface active agent included in the surface active processing part 8 is dissolved with the permeation of the liquid sample. By the action of the dissolved surface active agent, permeation into the reactive layer 14 is speedily performed and the permeation of the liquid sample is proceeded with the end of the permeating liquid being relatively uniformed and without remaining. On the area of the

reactive layer 14, there is the specific protein immobilization part 13 on which a specific protein is immobilized, and when the liquid sample includes an analysis target, the specific protein processes an antigen-antibody reaction with a complex of the analysis target and the marker reagent, resulting in some color reaction in the area of the specific protein immobilization part 13. The color reaction can be seen through the result confirmation window 16 provided in the water-absorbing part 15. When the liquid sample does not include an analysis target, the antigen-antibody reaction is not processed and no color reaction is shown. The liquid sample is finally absorbed into the water-absorbing part 15, and then the reaction is ended.

As described above, according to the flow through-type chromatography medium 20 of the second embodiment, the permeability of the reactive layer 14 is enhanced and a more uniform permeation is enabled by the impregnation processing and the drying processing of the surface active agent dissolved liquid on the flow through-type chromatography medium 20. The enhancement in the permeability and the uniform permeation improves the reactivity of the chromatography medium 20, resulting in a chromatography measurement with a higher sensitivity and a higher performance.

When the surface active agent used for the surface active agent dissolved liquid with which the reactive layer 14 is

coated include the surface active agent having such a property that it can be solidified when dried is adopted, the reactive layer 14 is in a completely dried condition till the liquid sample is applied thereto and permeates the reactive layer 14. Therefore, devitalization of the immobilized specific protein can be minimized, resulting in the enhanced preservation stability, the extended quality maintenance period, and the expanded storage condition of the chromatography medium 20.

When the surface active agent has an HLB value which is 20 or lower is adopted, it can be avoided that the permeation speed of the liquid sample in the reactive layer 14 becomes too high to obtain a sufficient reaction. Further, when the HLB value is selected to control its reaction speed appropriately, a chromatography measurement with a higher sensitivity and a higher performance can be realized.

When the surface active agent comprising the nonionic surface active agent is adopted, nonspecific adsorption of the marker reagent onto the reactive layer 14 can be avoided, whereby the marker reagent remains on the reactive layer 14 as a background and a measurement error of the color reaction in the specific protein immobilization part 13 can be prevented. As the result, the measurement with a higher sensitivity and a higher performance by the chromatography medium 20 is enabled.

Further, when the surface active agent comprising the cholic acid surface active agent is adopted, influence upon

protein can be reduced, and the denaturation or devitalization of the specific protein immobilized in the specific protein immobilization part 13 can be minimized, whereby the performance of the surface active processing part 8 can be held for a long time.

When the surface active agent comprising a sugar in its hydrophilic part is adopted, the solubility is enhanced and the permeability is increased by the action of sugar, while the denaturation or devitalization of the immobilized specific protein can be minimized since the influence upon protein is a little, whereby the performance of the surface active processing part 8 can be held for a long time.

When the reactive layer 14 is dried by the air drying, the load to the specific protein immobilized on the reactive layer 14 can be suppressed, whereby the performance of the medium 20 can be held for a long time.

When the reactive layer 14 is dried by wind drying, the drying time can be shorten and the deactivation or denaturation of the specific protein during the drying can be minimized, whereby the performance of the medium 20 can be held for a long time.

When the reactive layer 14 is dried by freeze drying, the property of the specific protein can be almost held, whereby the performance of the medium 20 can be held for a long time.

While in the second embodiment the description has been

given taking the specific protein as an example of the reactive component adopted in the chromatographic analysis, a reactive component such as an enzyme, which causes some changes before and after the reaction may be adopted as the reactive component as in the first embodiment.

A chromatographic analysis using an enzyme as a reactive component will be described with reference to figures 5 and 6.

Figures 5 and 6 are diagrams illustrating a structure of a flow through-type chromatography medium that adopts an enzyme.

A chromatography medium 30 has a sample application part 11, a reactive reagent impregnation region 17, a reactive layer 14, a surface active processing part 8, an enzyme immobilization part 7, and a water-absorbing part 15. The reactive reagent impregnation region 17 holds a reactive reagent on a nonwoven fabric or the like so that it can be dissolved by a liquid sample applied to the sample application part 11. The enzyme immobilization region 7 is obtained by immobilization and holding an enzyme that processes a binding reaction with an analysis target on the area of the reactive layer 14 according to the reaction format. The sample application part 11, the reactive layer 14, the surface active processing part 8 and the water-absorbing part 8 in the chromatography medium 30, except for the enzyme immobilization part 7 and the reactive reagent impregnation region 17, are the same as those of the aforementioned flow through-type

chromatography medium 20, and thus their description will be omitted.

A chromatographic analysis method by the flow through-type chromatography medium 30 that adopts an enzyme is the same as that by the aforementioned flow through-type chromatography medium 20. However, when the liquid sample includes an analysis target, some color reaction is seen in the area of the enzyme immobilization part 7 by the actions of the reactive reagent with which the reactive reagent impregnation region 17 is impregnated and the enzyme immobilized on the enzyme immobilization part 7.

Like for the flow through-type chromatography medium 20, also for the chromatography medium 30 that adopts the enzyme, the coating processing is performed to the reactive layer 14 using the surface active agent dissolved liquid in which the surface active agent having such a property that it can be solidified when dried is dissolved and then the drying processing is performed thereto, thereby achieving the same effects as those achieved in the flow through-type chromatography medium 20.

(Examples)

A method for implementing the present invention will be described in more detail through following examples.

(Quantitative analysis of hCG in blood plasma)

A lateral flow-type immunochromatography medium which



includes an anti-hCG- $\beta$  antibody immobilization line and a broad band of a complex of an anti-hCG- $\alpha$  antibody and gold colloid in a nitrocellulose film is manufactured. This medium is shown in figure 1. In this figure, the medium 10 holds the specific protein immobilization part 5 as the anti-hCG- $\beta$  antibody immobilization line; and the marker hold region 3 forward thereof, which is an area including the complex of the anti-hCG- $\alpha$  antibody and the gold colloid on the reactive layer 4 as a nitrocellulose film, and includes the sample application part 2 made of a nonwoven fabric and the water-absorbing part 6 made of glass fiber filter paper forward and backward thereof, respectively. The medium 10 is manufactured as follows.

(Example 1)

Preparation of lateral flow-type immunochromatography medium

An anti-hCG- $\beta$  antibody solution which was diluted with a phosphate buffer solution to control the concentration was prepared. This antibody solution was applied on the nitrocellulose film by adopting a solution discharge device. Thereby, a detecting antibody immobilization line was obtained on the nitrocellulose film. After being dried, this nitrocellulose film was immersed in a Tris-HCl buffer solution including 1% skim milk and shaken gently for 30 minutes. 30 minutes later, the nitrocellulose film was moved into a Tris-HCl buffer solution tank, shaken gently for 10 minutes, and

thereafter shaken gently in another Tris-HCl buffer solution tank for another 10 minutes, to wash the nitrocellulose film. After washed twice, the nitrocellulose film was immersed in a Tris-HCl buffer solution including 0.05% Sucrose Monolaurate (Dojindo made), shaken for 10 minutes, then taken out from the solution tank, and dried at room temperatures. Accordingly, the specific protein immobilization part 5 was obtained on the nitrocellulose film as the reactive layer 4.

The gold colloid was prepared by adding 1% citric acid solution to a refluxing 100°C-solution of 0.01% chloroauric acid. After the reflux was continued for 30 minutes, it was cooled. The anti-hCG- $\alpha$  antibody was added to gold colloid solution which was prepared to pH9 by using 0.2M potassium carbonate solution, then the obtained solution was stirred for several minutes, and then 10% BSA (bovine serum albumin) solution pH9 was added thereto by such an amount that 1% solution was finally obtained and stirred. Thereby, an antibody-gold colloid complex (marker antibody) was prepared. The marker antibody solution was centrifuged at 4°C and 20000G for 50 minutes, whereby the marker antibody was isolated, and the isolated marker antibody was suspended in a washing buffer solution (1% BSA-phosphate buffer solution) and thereafter centrifuged to wash and isolate the marker antibody. After suspended in the washing buffer solution and filtrated through a 0.8 $\mu$ m filter, the marker antibody was prepared one-tenth as

much as the initial gold colloid solution and stored at 4°C.

The marker antibody solution was set in the solution discharge device and applied to a position on an anti-hCG- $\beta$  antibody immobilization dry film, apart from an antibody immobilization position, and thereafter the film was dried. Thereby, the marker antibody hold region 3 was obtained on the immobilization film.

The antibody immobilization film including the marker antibody hold region 3 prepared as described above was affixed on the reactive layer carrier support 1, a nonwoven fabric was added thereto as the sample application part 2, glass fiber filter paper was added thereto as the water-absorbing part 6, and thereafter the film was cut into small pieces of 0.5cm width, thereby manufacturing the medium 10.

(Example 2)

#### Preparation of sample

Human blood to which heparin was added as an anticoagulant was centrifuged at 4000 rpm for 5 minutes to prepare blood plasma in which blood cells were separated. The hCG solutions of known concentrations were added to the plasma, thereby preparing the hCG solutions of various known concentrations.

(Example 3)

Measurement of the degree of coloration on immunochromatography medium

More than 200 $\mu$ l of plasma including hCG was applied to the sample application part 1 on the medium 10 and spread in the direction of the water-absorbing part 6, to process an antigen-antibody reaction, whereby a color reaction in the specific protein immobilization part 5 on which the anti-hCG- $\beta$  antibody was immobilized was processed. The coloration state 5 minutes after the sample application to the medium 10 was measured by adopting a reflective spectrophotometer (CS9300; Shimadzu Corporation made), and the coloration degree is computed.

In this example, plasmas including hCG of 0, 100, 1000, and 10000U/l were applied to the medium 10 to be spread, and the coloration state of the antibody immobilization part 5 on the medium 10 for plasma of each hCG concentration was measured by the reflective spectrophotometer. An absorbance at the wavelength of 520nm was measured by the reflective spectrophotometer, and substituted into a previously formed calibration curve indicating a relationship between the hCG concentration and the absorbance. The result is shown in figure 7. Essentially, when for example blood including hCG of 1000U/l was applied onto each medium 10, the absorbance of the color area of each medium 10 was measured, and the measured absorbance in each medium 10 was substituted into the calibration curve to obtain the hCG concentration, its value should be all 1000U/l. However, a value actually obtained by

the substitution into the calibration curve slightly deviates from 10000U/1 according to the reaction condition in each medium 10. That is, the accuracy of measurement in each medium 10 can be known by the amount of the deviation.

Figures 7 are diagrams illustrating quantitative performances in the immunochromatography medium formed as described above, figure 7(a) showing a case where the reactive layer is not processed with a surface active agent and figure 7(b) showing a case where it is processed with the surface active agent. The abscissa represents the hCG concentration of a sample applied to the medium 10. The ordinate represents the converted value of the antigen concentration obtained by substituting the absorbance from a marker in the color area on the medium 10 into the calibration curve.

Hereinafter, descriptions will be given of effects in a case where the reactive layer 4 is not processed with a surface active agent and a case where it has been processed with the surface active agent in the immunochromatography medium 10. The reactive layer which has been processed with a surface active agent shown here is one that is washed twice in a Tris-HCl buffer solution, then immersed in a Tris-HCl buffer solution including 0.05% Sucrose Monolaurate and shaken gently for 10 minutes, and thereafter dried by leaving the same at room temperatures, as shown in the Example 1. The reactive layer which is not processed indicates one that is washed twice

in the Tris-HCl buffer solution and dried by leaving the same at room temperature.

Figures 7 show the result obtained by converting the concentration of an analysis target on the basis of a measured value of a coloration degree, five minutes after a liquid sample is applied to the immunochromatography medium 10. The marker reagent used at this time is the same antibody-gold colloid complex both in figures 7(a) and 7(b). In a case where the reactive layer 4 has been processed with a surface active agent (figure 7(b)), a CV value (coefficient of variation) is within 0 to 7%, while in a case where it is not processed with a surface active agent (figure 7(a)), the CV value ranges from 15 to 35% having a wide range of variations, and has a low quantitative performance. From the above results, it can be understood that the use of the reactive layer which has been impregnated with the surface active agent in the immunochromatography medium 10 greatly concerns the enhancement in the quantitative performance. While in this example the comparison description has been given with respect to the quantitative performance, a more accurate result is obtained also in a qualitative test when a chromatography medium having a reactive layer which is impregnated with a surface active agent is adopted.

Since the gold colloid is adopted as the marker in this example, the coloration degree with a wavelength of 520nm is

measured. However, an absorbance with any wavelength may be measured as long as it is an absorption wavelength of the marker.

#### APPLICABILITY IN INDUSTRY

A chromatography medium and its manufacturing method according to the present invention are significantly useful as one which enhances the permeation speed and the permeability in a reactive layer of the chromatography medium, uniforms the permeability, and enhance the measurement efficiency in the chromatography medium.